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(54) MAGNETIC THIN FILM MEMORY DEVICE AND METHOD FOR RECORDING INFORMATION, METHOD FOR REPRODUCING INFORMATION USING THE SAME

(57)Abstract:
PROBLEM TO BE SOLVED: To reduce the cell width of one bit and enhance the integration degree by using two magnetic layers of a closed magnetic circuit structure and regulating the length range of a generated magnetic field.
SOLUTION: In this magnetic thin film memory device, a first magnetic layer of a closed magnetic circuit structure and a second magnetic layer of a closed magnetic circuit structure having coercive force higher than the first magnetic layer are layered via a non-magnetic layer. The first, second magnetic layer has an axis of easy magnetization in left turning or right turning, showing a different resistance value in accordance with a relative angle of directions of magnetization of the first, second magnetic layers. A current is supplied perpendicularly to film faces of the first, second magnetic layers, whereby a length of a current path where information is to be recorded by a generated magnetic field is set to be 0.05-2 μm. Moreover, the current is supplied upward or downward perpendicularly to a film face of the magnetic thin film memory element beforehand, and a size of the current is set to generate the magnetic field larger than a magnetization inverted magnetic field of the second magnetic layer.

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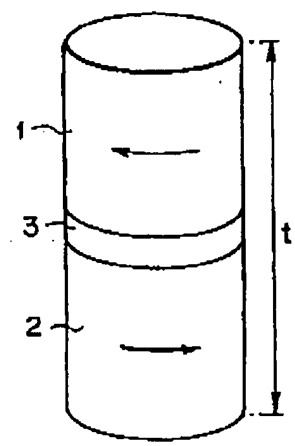
(54)【発明の名称】 磁性薄膜メモリ素子及びそれを用いた情報記録方法、情報再生方法

(57)【要約】
【課題】 ビットセルの面積を小さくするほど反磁界が無視できなくなり、磁性層の磁化方向が一定方向に定まらず不安定になる。
【解決手段】 第1，第2の磁性層1，2の膜面に対し垂直方向に電流を供給し、発生する磁界によって情報を記録する電流路の長tを0．05μm以上、0．2μm以下とする。



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1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Carry out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and it changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] The magnetic-thin-film memory device characterized by setting the die length of the current path which is the magnetic-thin-film memory device which has different resistance, supplies a current perpendicularly to the film surface of said 1st and 2nd magnetic layer, and records information by the field to generate to 0.05 micrometers or more and 2 micrometers or less.
[Claim 2] For the field which touches said non-magnetic layer of said 1st magnetic layer, the field of the opposite side or the field which touches said non-magnetic layer of said 2nd magnetic layer is a magnetic-thin-film memory device according to claim 1 characterized by forming a good conductor layer with high conductivity, and constituting said current path from said 1st and 2nd magnetic layer at least in one side of the field of the opposite side including said 1st and 2nd magnetic layer, a non-magnetic layer, and said good conductor layer.
[Claim 3] The magnetic-thin-film memory device according to claim 1 characterized by preparing the good conductor for current supply sources with conductivity higher than said 1st and 2nd magnetic layer in the abbreviation core of the film surface of said 1st and 2nd magnetic layer and said non-magnetic layer through an insulating layer to a film surface perpendicularly.
[Claim 4] It is the approach of recording information on the magnetic-thin-film memory device of claim 1. Beforehand By setting up so that a current may be perpendicularly supplied facing up or downward to the film surface of said magnetic-thin-film memory device and a larger field than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current It is not concerned with recording information but the sense of magnetization of said 2nd magnetic layer is defined in the predetermined direction. Subsequently, according to recording information, a current is perpendicularly supplied facing up or downward to the film surface of said magnetic-thin-film memory device. And the information record approach characterized by recording information on said 1st magnetic layer according to the sense of the magnetization by setting up so that it may be larger than the flux reversal field of said 1st magnetic layer and a field smaller than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current.
[Claim 5] Carry out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and it changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] It is the approach of recording information on the magnetic-thin-film memory device which has different resistance. By setting up so that a current may be perpendicularly supplied facing up or downward according to recording information to the film

surface of said memory device and a larger field than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current The information record approach characterized by recording information on said 2nd magnetic layer according to the sense of the magnetization.

[Claim 6] Carry out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and it changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] Are the approach of reproducing the information recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device which has different resistance, and a current is perpendicularly supplied to the film surface of said magnetic-thin-film memory device. The information playback approach characterized by reproducing recording information by arranging magnetization of said 1st magnetic layer in the predetermined direction, initializing it, and measuring the resistance of said magnetic-thin-film memory device in this condition.

[Claim 7] Carry out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and it changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction, and it has the resistance which changes with whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer]. It is the approach of reproducing the information on which magnetization of said 1st magnetic layer and magnetization of said 2nd magnetic layer were recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device put on parallel or the condition of anti-parallel in the condition that a field is not impressed. Measure the resistance of the introduction aforementioned magnetic-thin-film memory device, and then a current is perpendicularly supplied to the film surface of a magnetic-thin-film memory device. The information playback approach characterized by reproducing recording information by measuring the resistance of said magnetic-thin-film memory device again, and measuring the resistance change in this case after making the orientation of the magnetization of said 1st magnetic layer carry out in the predetermined direction.

[Claim 8] Carry out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and it changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] It is the approach of reproducing the information recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device which has different resistance. Supply a current to said 2nd magnetic layer from one field, reverse magnetization of said 1st magnetic layer, and the resistance of said magnetic-thin-film memory device is measured. Subsequently, the information playback approach characterized by supplying a current from a field opposed to said memory device, reversing magnetization of said 1st magnetic layer, measuring the resistance of said magnetic-thin-film memory device, and reproducing recording information based on obtained resistance change.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention records information with the sense of magnetization, and relates to the information record approach and the information playback approach using the magnetic-thin-film memory device and it which reproduce recording information using a magneto-resistive effect.
[0002]
[Description of the Prior Art] Conventionally, magnetic-thin-film memory is known as semiconductor memory and solid-state memory which does not have the migration section similarly. Even if the radiation with which information does not disappear even if a power source is intercepted and whose informational count of repeat rewriting is an infinity time carries out incidence of such magnetic-thin-film memory, it has many advantageous points as compared with semiconductor memory -- there is no danger that information will disappear. Since a big output is obtained as compared with the magnetic-thin-film memory using the conventional anisotropy magneto-resistive effect, especially the thin film MAG memory that used the huge magnetic-reluctance (GMR) effectiveness in recently attracts attention.
[0003] for example, the Magnetics Society of Japan -- as shown in drawing 8 , the solid-state memory which carried out the laminating of a hard magnetic film (HM), a nonmagnetic membrane (NM), the soft magnetism film (SM), and the nonmagnetic membrane (NM), and was used as the memory device is proposed by VOL.20.P22 (1996). Sense line S combined with the metallic conductor like drawing 8 and word line W insulated with sense line S by the insulator layer I are prepared in this memory device, and information is written in it by the field generated according to the current of this word line W, and the current of sense line S.
[0004] If it explains concretely, Current I is supplied to word line W, by generating the field of the direction which changes with sense ID of a current, flux reversal of the hard magnetic film HM will be performed, and record of a memory condition "0" and "1" will be performed. For example, if a forward current is supplied to word line W as shown in drawing 9 (a), a rightward field is generated like drawing 9 (b), and "1" can be recorded on the hard magnetic film HM. Moreover, if a negative current is supplied to word line I like drawing 9 (c), a leftward field is generated like drawing 9 R> 9 (d), and "0" can be recorded on the hard magnetic film HM.
[0005] On the other hand, when reading information, a current smaller than the current at the time of record is supplied to word line W, and information is read by detecting a lifting and the resistance change in that case only for the flux reversal of the soft magnetism film SM. Since resistance differs by the case where it is a direction opposite to the case where magnetization of the soft magnetism film SM and the hard magnetism film HM is this direction when giant magneto-resistance is used, the memory condition of "1" and "0" is distinguished by resistance change then produced. If the pulse which changes from forward to negative is specifically impressed as shown in drawing 10 (a) The magnetization direction of the soft magnetism film SM changes from the rightward condition of drawing 10 (b) to the leftward condition of drawing 10 R> 0 (c). In the case of a memory condition "1", magnetization of the

hard magnetic film HM and the soft magnetism film SM changes from resistance with magnetization of the hard magnetic film HM and the soft magnetism film SM small in this direction to the large resistance of an opposite direction. Moreover, in the case of a memory condition "1", it changes from large resistance to small resistance like drawing 10 (e) like drawing 10 (d). Therefore, by reading such a resistance value change, irrespective of the magnetization condition of the soft magnetism film SM after record, read-out of the information recorded on the hard magnetic film HM becomes possible, and destructive read can be performed.

[0006]
[Problem(s) to be Solved by the Invention] However, in the above-mentioned conventional thin film MAG memory, there was a problem that the magnetization direction of the magnetic layer which it becomes impossible to disregard the anti-field (self-demagnetizing field) produced inside a magnetic layer, and carries out record maintenance did not become settled in the fixed direction, but became unstable, so that area of a bit cel was made small. Therefore, it was not fully able to be integrated highly by there being a limit in making a bit cel detailed.

[0007] In view of the above-mentioned conventional trouble, this invention loses the effect of an anti-field of a magnetic film, and aims at offering the information record approach using the magnetic-thin-film memory device and it which can be integrated more highly, and the information playback approach.

[0008]
[Means for Solving the Problem] The purpose of this invention carries out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] Are the magnetic-thin-film memory device which has different resistance, and a current is perpendicularly supplied to the film surface of said 1st and 2nd magnetic layer. It is attained by the magnetic-thin-film memory device characterized by setting the die length of the current path which records information by the field to generate to 0.05 micrometers or more and 2 micrometers or less.

[0009] The purpose of this invention is the approach of recording information on the magnetic-thin-film memory device of claim 1. By setting up so that a current may be perpendicularly supplied facing up or downward to the film surface of said magnetic-thin-film memory device and a larger field than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current beforehand It is not concerned with recording information but the sense of magnetization of said 2nd magnetic layer is defined in the predetermined direction. Subsequently, according to recording information, a current is perpendicularly supplied facing up or downward to the film surface of said magnetic-thin-film memory device. And by setting up so that it may be larger than the flux reversal field of said 1st magnetic layer and a field smaller than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current It is attained by the information record approach characterized by recording information on said 1st magnetic layer according to the sense of the magnetization.

[0010] The purpose of this invention carries out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] It is the approach of recording information on the magnetic-thin-film memory device which has different resistance. By setting up so that a current may be perpendicularly supplied facing up or downward according to recording information to the film surface of said memory device and a larger field than the flux reversal field of said 2nd magnetic layer may generate the magnitude of a current It is attained by the information record approach characterized by recording information on said 2nd magnetic layer according to the sense of the magnetization.

[0011] The purpose of this invention carries out the laminating of the 1st magnetic layer of closed

magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] Are the approach of reproducing the information recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device which has different resistance, and a current is perpendicularly supplied to the film surface of said magnetic-thin-film memory device. Magnetization of said 1st magnetic layer is arranged in the predetermined direction, and is initialized, and it is attained by the information playback approach characterized by reproducing recording information by measuring the resistance of said magnetic-thin-film memory device in this condition.

[0012] The purpose of this invention carries out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction, and it has the resistance which changes with whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer]. It is the approach of reproducing the information on which magnetization of said 1st magnetic layer and magnetization of said 2nd magnetic layer were recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device put on parallel or the condition of anti-parallel in the condition that a field is not impressed. Measure the resistance of the introduction aforementioned magnetic-thin-film memory device, and then a current is perpendicularly supplied to the film surface of a magnetic-thin-film memory device. After making the orientation of the magnetization of said 1st magnetic layer carry out in the predetermined direction, it is attained by the information playback approach characterized by reproducing recording information by measuring the resistance of said magnetic-thin-film memory device again, and measuring the resistance change in this case.

[0013] The purpose of this invention carries out the laminating of the 1st magnetic layer of closed magnetic circuit structure, and the 2nd magnetic layer of the closed magnetic circuit structure of having coercive force higher than said 1st magnetic layer, through a non-magnetic layer, and changes. Said 1st and 2nd magnetic layer has an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of said 1st and 2nd magnetic layer] It is the approach of reproducing the information recorded according to the sense of magnetization of said 2nd magnetic layer in the magnetic-thin-film memory device which has different resistance. Supply a current to said 2nd magnetic layer from one field, reverse magnetization of said 1st magnetic layer, and the resistance of said magnetic-thin-film memory device is measured. Subsequently, it is attained by the information playback approach characterized by supplying a current from a field opposed to said memory device, reversing magnetization of said 1st magnetic layer, measuring the resistance of said magnetic-thin-film memory device, and reproducing recording information based on obtained resistance change.

[0014]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained to a detail with reference to a drawing. Drawing 1 is drawing showing the configuration of 1 operation gestalt of the magnetic-thin-film memory device of this invention. In drawing 1 R> 1, 1 is the cylinder-like 1st magnetic layer, and 2 is the cylinder-like 2nd magnetic layer. The non-magnetic layer 3 is formed between the 1st and 2nd magnetic layer 1 and 2. The memory device of a 1-bit cel consists of the 1st and 2nd magnetic layer 1 and 2 of drawing 1 , and a non-magnetic layer 3. The 1st and 2nd magnetic layer 1 and 2 has an easy shaft left-handed rotation or in the clockwise direction, and is carrying out orientation of the magnetization annularly in accordance with the cylinder-like configuration. The arrow head of drawing 1 shows the magnetization direction in the 1st and 2nd magnetic layer 1 and 2. In addition, magnetization should just be carrying out orientation of the magnetic layer to the closed magnetic circuit not only with the shape of a cylinder but with structure with a square cross section. However, since columnar structure turns into most stable closed magnetic circuit structure, it is desirable.

[0015] Moreover, this operation gestalt shows resistance with the resistance low when the magnetization direction of the 1st and 2nd magnetic layer 1 and 2 is this direction between the 1st and 2nd magnetic layer 1 and 2, and when the 1st and 2nd magnetization direction is an opposite direction, high resistance is shown with it. Thus, since the resistance of a memory device changes with magnetization directions of the 1st magnetic layer 1, magnetization information can be read using this. Moreover, "0" or "1" magnetization information is made to correspond 1st and 2nd in the clockwise direction [of magnetic layers 1 and 2 / of the magnetization direction / left-handed rotation or in the clockwise direction], and is recorded. Namely, a current is supplied perpendicularly (the direction of t of drawing 1) facing up or downward to the film surface of the 1st and 2nd magnetic layer 1 and 2, and it carries out by reversing magnetization of the 1st magnetic layer 1 or the 2nd magnetic layer 2 by the field generated by this. About informational record and the informational playback approach, it mentions later in detail. With this operation gestalt, since the 1st and 2nd magnetic layer 1 and 2 has closed magnetic circuit structure, the effect of an anti-field can be lost, it is stabilized, and magnetization information can be recorded. Therefore, a 1-bit cell size can be made small and a memory apparatus with a high degree of integration can be realized, and a leakage field does not leak to a contiguity cel further, it is stabilized, and record playback can be performed.
[0016] Drawing 2 is drawing showing an example in the case of actually constituting as memory using the memory device of drawing 1 . In drawing 2 , first, on the semi-conductor substrate, the memory device which consists of the 1st and 2nd magnetic layers 1 and 2 and non-magnetic layer 3 is made into the transistor for a drive, and a pair, and is prepared. This semi-conductor substrate consists for example, of a p type semiconductor substrate, and the source and a drain field serve as a n-type semiconductor. Signal is for example, the source terminal of the transistor for a drive, Select is a gate terminal, and a memory device is electrically connected to a drain terminal. The opposite side of a memory device is connected to VDD. VDD is supply voltage, by switching the polarity of VDD according to recording information, changes the sense of the current of a memory device and records "1" of magnetization information, and "0." On a semi-conductor substrate, many memory devices and transistors for a drive are arranged in all directions, and are integrated as magnetic-thin-film memory of high integration.
[0017] Here, with this operation gestalt, when recording information, the type of a memory device is divided into two by whether magnetization of the 1st magnetic layer 1 is reversed, or magnetization of the 2nd magnetic layer 2 is reversed. First, the 1st type is a configuration used as a memory layer (the 1st magnetic layer 1), a non-magnetic layer 3, and a pin layer (the 2nd magnetic layer 2). This reverses the 1st magnetic layer 1 according to a record current by the case where the memory layer for saving magnetization information for the 1st magnetic layer 1 and the 2nd magnetic layer 2 are used as the pin layer for always keeping it constant also in the state of any at the time of playback at the time of record at the time of preservation, without depending for the magnetization direction on magnetization information. It carries out by absolute value detection, without performing reversal of a magnetic layer so that informational playback may be mentioned later.
[0018] The 2nd type is a configuration used as a detection layer (the 1st magnetic layer 1), a non-magnetic layer 3, and a memory layer (the 2nd magnetic layer 2). This reverses the 2nd magnetic layer 2 according to a record current by the case where the detection layer and the 2nd magnetic layer 2 which are reversed in order to read the 1st magnetic layer 1 and to sometimes carry out relative detection are used as the memory layer for saving magnetization information. Having coercive force with the 1st low magnetic layer 1 in any case, the 2nd magnetic layer 2 needs to have coercive force higher than the 1st magnetic layer 1.
[0019] Next, the fully stabilized record is possible for the magnetic-thin-film memory device of this operation gestalt by lengthening die-length t of the current path to which a record current flows. this -- the 1st above-mentioned type and the 2nd type -- in any case and any [of the spin tunnel film configuration mentioned later or a spin dispersion film configuration] case, it is the same. Hereafter, the concrete configuration of a memory device is explained. First, in order to record information on a memory device, it is desirable still more desirable to generate the field more than at least 5 (Oe), and the field more than 10 (Oe) is good. This is because it is difficult to also make small coercive force of a

magnetic-thin-film memory device, to stabilize it, and to hold recording information when a field is too small. Although what is necessary is just to pass many currents in order to acquire a big field, if electromigration will occur and it will become easy to disconnect wiring, if the limiting current density of a wiring material is exceeded, and a current value becomes large, the power consumption of a memory device will become large.

[0020] the limiting current density of the tungsten wire which is the ingredient which has comparatively big limiting current density among the wiring materials used with a semiconductor device -- 20mA/micrometer2 it is . Moreover, a current desirable although the increment in power consumption, generation of heat of a device, etc. are suppressed is about 1mA or less. Here, drawing 3 uses the above tungsten wires as a cylinder-like conductor, and shows R and die length for the radius of a conductor as t. Drawing 4 shows relation with the field generated when a current is supplied to the radius R of the conductor of drawing 3 , and the longitudinal direction of a conductor. In addition, in drawing 4 , the generating field H is plotted to a radius R by making die-length t of a conductor into a parameter. Die-length t of a conductor may be 0.01, 0.03, 0.05, 0.1, 0.2, and 0.3 micrometers.

[0021] Moreover, drawing 5 is die-length t of a conductor, and the maximum field Hmax. Relation is shown. In order to acquire the field more than 5 [required for record] (Oe) so that clearly from drawing 4 and drawing 5 , die length of at least 0.05 micrometers or more is required for die-length t of a current path. Moreover, it turns out that the range of the radius R of an available current path can be extended to record, so that drawing 4 may show and die-length t of a current path becomes long, and the margin on manufacture of a memory device becomes large. In order to generate the field 5 required for record (Oe) from the above result, die length of 0.05 micrometers is required for die-length t of a current path, and its 0.2 micrometers or more 0.15 micrometers or more 0.1 micrometers or more are still more preferably good still more preferably preferably. Moreover, it becomes the cause of incorrect record [record / accidentally / memory device / which will incline without a memory device becoming perpendicular to the semi-conductor substrate of membrane formation not only taking time amount but drawing 2 since thickness will become thick if die-length / of a current path / t is lengthened not much, and adjoins]. For this reason, die-length t of a current path has preferably still more preferably good 0.5 micrometers or less 1 micrometer or less 2 micrometers or less. Therefore, as die-length [of the current path of the memory device of drawing 1] t, it is good to be referred to as 0.05 micrometers or more and 2 micrometers or less.

[0022] Drawing 6 is drawing showing the 2nd operation gestalt of this invention. Although the current path at the time of record is formed with the operation gestalt of drawing 1 by the 1st magnetic layer 1, the non-magnetic layer 3, and the 2nd magnetic layer 2, the good conductor 4 is further formed with this operation gestalt. That is, when thickness of the 1st and 2nd magnetic layer 1 and 2 cannot be thickened, the die length of a current path is secured by forming a good conductor 4. It records on the 1st and 2nd magnetic layer 1 and 2 by supplying a current perpendicularly at the memory device of drawing 6 , using what has conductivity higher than the 1st and 2nd magnetic layer 1 and 2 as a good conductor 4. A good conductor 4 may be formed in the field of the opposite side with the field where the field of the opposite side and the non-magnetic layer 3 of the 2nd magnetic layer 2 touch the field where a non-magnetic layer 3 touches among the end faces of the 1st magnetic layer 1, as shown in drawing 6 , or it may be prepared in one of fields. Thus, by forming a good conductor 4, the resistance loss of a memory device decreases and power consumption can be reduced.

[0023] Drawing 7 is drawing showing the 3rd operation gestalt of this invention. With this operation gestalt, the conductor 5 for supplying a record current to the core of a memory device is formed. The conductor 5 is covered with the insulator 6 and uses what has conductivity higher than the 1st and 2nd magnetic layer 1 and 2. The insulator 6 is formed in order for a conductor 5 to prevent contacting a magnetic layer electrically, but since the distance of a conductor 5 and each magnetic layer will become far and the field impressed to a magnetic layer will become small if the thickness of an insulator 6 is thick, the thinner one as much as possible is good. With this operation gestalt, since a current is not supplied to a magnetic layer at the time of record but a conductor 5 is supplied, resistance becomes small, and power consumption can be reduced, and it excels also in responsibility.

[0024] Next, the concrete approach of recording information on a magnetic-thin-film memory device is explained. First, for recording information on a memory device, a current is perpendicularly supplied to the film surface of a memory device. That is, a current is supplied so that it may become perpendicular to the magnetization direction, by the field produced according to this current, the magnetization direction of a memory layer is determined and the information on "0" and "1" is recorded. In this case, since the sense of the magnetic field generated with the sense of the current to pass differs, if a current is supplied downward, for example from on a memory device, it will see from the upper part of a memory device, a field will occur in the direction of clockwise, and orientation of the magnetization will be carried out in the direction of clockwise. On the other hand, if a current is supplied upwards from under a memory device, it will see from the upper part of a memory device, a field will occur counterclockwise, and orientation of the magnetization will be carried out in the direction of counterclockwise.
[0025] the 1st type "a memory layer (the 1st magnetic layer 1), a non-magnetic layer 3, and a pin layer (the 2nd magnetic layer 2)" above when actually recording information, and the 2nd type -- " (the record approaches differ in the detection layer (the 1st magnetic layer 1), the non-magnetic layer 3, and the memory layer (the 2nd magnetic layer 2)".) With the configuration of the 1st type, it is smaller than the flux reversal field of a pin layer (the 2nd magnetic layer 2) in the magnitude of the current to pass, and "0" or "1" information can be recorded on a memory layer (the 1st magnetic layer 1) according to the sense of the magnetization by setting up so that a larger field than the flux reversal field of a memory layer (the 1st magnetic layer 1) may be generated. Moreover, in the 2nd type, according to the sense of the magnetization, "0" or "1" information is recordable on a memory layer by setting up so that a larger field than the flux reversal field of a memory layer (the 2nd magnetic layer 2) may generate the magnitude of the current to pass.
[0026] Next, the concrete approach of reproducing the recording information of magnetic-thin-film memory is explained. First, informational playback supplies a current perpendicularly to the film surface of a memory device in order of the order of the 1st magnetic layer 1, a non-magnetic layer 3, and the 2nd magnetic layer 2 or the 2nd magnetic layer 2, a non-magnetic layer 3, and the 1st magnetic layer 1. And the magnetization information on "0" and "1" is detected by measuring the resistance between the 1st magnetic layer 1 of a memory device, and the 2nd magnetic layer 2. That is, when the magnetization direction of the 1st magnetic layer 1 and the 2nd magnetic layer 2 is this direction, the resistance between the 1st and 2nd magnetic layer is small, and since resistance is large, in the case of an opposite direction, information is distinguished by the difference in this resistance. Or a current is horizontally supplied to the film surface of a memory device, and the difference in resistance is detected similarly.
[0027] Moreover, the read-out approaches differ by the 1st type and 2nd type of a memory device. First, in the 1st type, the current smaller than the time of record for reading is perpendicularly supplied to the film surface of a memory device, and it measures the resistance between the 1st and 2nd magnetic layer 1 and 2. In this case, since it is fixed, corresponding to the magnetization direction recorded on the 1st magnetic layer 1, the resistance between the 1st and 2nd magnetic layer 1 and 2 changes, and magnetization of the 2nd magnetic layer 2 reproduces recording information with that resistance. In addition, the flux reversal of a magnetic layer is unnecessary in this case.
[0028] On the other hand, in the 2nd type, there are the three approaches of reading. First, a current is perpendicularly supplied to the film surface of a memory device, and one reverses a detection layer (the 1st magnetic layer), and it arranges magnetization in the fixed direction and initializes it. Subsequently, the weak current for reading which is extent which a detection layer does not reverse is perpendicularly supplied to the film surface of a memory device, and the resistance between the 1st and 2nd magnetic layer 1 and 2 is measured. This approach has the small coercive force of a detection layer, and is effective to a component in which that magnetization is carrying out orientation at random.
[0029] First, another measures the resistance of a memory device first, then supplies a current perpendicularly at the film surface of a memory device, makes the orientation of the magnetization of a detection layer carry out in the predetermined direction, and measures the resistance of a memory device further. The magnetization information on a memory device is detectable by whether there is any change

of the resistance in this case, or there is nothing. By this approach, after record is completed, the magnetization direction of a detection layer and a memory layer is set up, as it has the decided relation. For example, let the resistance first measured as a detection layer and a memory layer are magnetic interactions and become stable [an parallel magnetization condition] be the resistance of an parallel magnetization condition. This is attained by making thickness of a non-magnetic layer into 10A - about 20A thickness for example, in a spin tunnel mold.

[0030] The last one supplies a current perpendicularly from one direction to a film surface at a memory device, and it reads the resistance change between the 1st and 2nd magnetic layer 1 and 2. Next, with the direction of previous, a current is supplied to an opposite direction at a memory device, the resistance change between the 1st and 2nd magnetic layer 1 and 2 is read, and recording information is distinguished by obtained resistance change. Magnitude of a current is made into the current which reverses only a detection layer. Moreover, it is required to make it not reversed [a memory layer (the 2nd magnetic layer)] in [any] an approach.

[0031] CPP(Current Perpendicular to the film Plane)-MR which passes a current perpendicularly to a film surface with this operation gestalt at the time of playback as mentioned above (Magneto-Resistance) Effectiveness or the CIP (Current In-Plane to the film Plane)-MR effectiveness of passing a current in parallel with a film surface is used. In addition, the current passed at right angles to a film surface by **** in order to define the magnetization direction of a magnetic layer, and the current passed in order to measure the resistance of a memory device take the same current path in the memory device shown in drawing 1 and drawing 6 .

[0032] Moreover, with the configuration of the memory device shown in drawing 7 , the current to which the current which defines the magnetization direction measures a sink and resistance to a conductor 5 is passed between the 1st magnetic layer 1 and the 2nd magnetic layer 2. The optimal operation gestalt in this case is shown in drawing 11 and drawing 12 as 4th and 5th operation gestalt, respectively. With this configuration, although drawing 11 shows the sectional view of the memory device of the 4th operation gestalt, when defining the magnetization direction, it establishes the potential difference among conductors 71 and 72, and passes a current to a conductor 5. When measuring the resistance of a memory device, a current is passed between the electrodes 61 and 63 which consist of a conductor prepared in the top face of the 1st magnetic layer 1, and the electrodes 62 and 64 which consist of a conductor prepared in the inferior surface of tongue of the 2nd magnetic layer 2. This is the case of CPP detection, and when detecting the component of both the types of the spin tunnel mentioned later and spin dispersion, it is used.

[0033] Although the sectional view of the memory device of the 5th operation gestalt is shown, with this configuration, the configuration of drawing 12 has deleted the electrodes 62 and 64 of drawing 11 , and when measuring resistance, it passes a current to an electrode 61 and an electrode 63. In this case, it is CIP detection, and it is used when detecting the component of the type of spin dispersion mentioned later. The component of spin dispersion has the thin thickness of a magnetic layer, and is good to use CIP detection desirably in CPP detection, since resistance is small.

[0034] Next, the ingredients and those thickness of the 1st and 2nd magnetic layer of a magnetic-thin-film memory device and a non-magnetic layer are explained. Here, as a memory device film configuration, a spin tunnel film configuration and a spin dispersion film configuration can be taken, and this can be applied to any configuration of "the memory layer / non-magnetic layer / pin layer" of the 1st above-mentioned type, and "the detection layer / non-magnetic layer / memory layer" of the 2nd type. However, it is desirable to use a spin tunnel film configuration with a spin tunnel film configuration and a spin dispersion film configuration. This is for obtaining a big magnetic-reluctance (MR) ratio with a spin tunnel film configuration, and being able to enlarge more than 1kohm and resistance for the resistance, and being hard to be influenced of dispersion in the on resistance (about 1 about k ohms) of a solid-state-switching component. Moreover, although it is employable as drawing 1 , drawing 6 , and any operation gestalt of drawing 7 since the spin tunnel film can make a magnetic film comparatively thick so that it may mention later, as for the spin dispersion film, it is desirable to use the thickness of all magnetic layers and a non-magnetic layer for drawing 6 or the operation gestalt of drawing 7 , since it is

difficult for 0.05 micrometers or more to thicken.

[0035] As for the 1st magnetic layer and the 2nd magnetic layer, it is desirable to use as an amorphous alloy of nickel, Fe, and Co which uses CoFe as a principal component at least, using a kind as a principal component. For example, it consists of magnetic films, such as NiFe, NiFeCo, Fe, FeCo, Co, and CoFeB.

[0036] (Ingredient of the 1st magnetic layer) The 1st magnetic layer has coercive force lower than the 2nd magnetic layer. For this reason, the soft magnetism film which contains nickel in the 1st magnetic layer is desirable, and it is especially specifically desirable to use NiFe and NiFeCo as a principal component. Moreover, the low amorphous magnetic film of coercive force, such as a magnetic film with many Fe presentations at FeCo and CoFeB, is sufficient.

[0037] the case where the atomic composition ratio of NiFeCo sets to NixFeyCoz -- x -- 95 or less [40 or more] and y -- 40 or less [0 or more] and z -- 50 or less [0 or more] -- desirable -- x -- as for 25 or less [10 or more] and z, 30 or less [0 or more] are [x / 85 or less / 60 or more / and y] still more preferably good [90 or less / 50 or more and y / 30 or less / 0 or more / and z / 40 or less / 0 or more /.

[0038] Moreover, the atomic composition of FeCo is FexCo 100-x. As for x, 90 or less [60 or more] are [x / 100 or less / 50 or more] preferably good, when it carries out. Moreover, the atomic composition of CoFeB is 100(Cox Fe 100-x)-y By. When it carries out, as for 93 or less [86 or more] and y, 25 or less [10 or more] are [x] good.

[0039] (Ingredient of the 2nd magnetic layer) The 2nd magnetic layer has coercive force higher than the 1st magnetic layer. The magnetic film which contains many Co(es) as an example as compared with the 1st magnetic layer is desirable. NixFeyCoz -- respectively -- an atomic composition ratio -- it is -- x -- 40 or less [0 or more] and y -- 50 or less [0 or more] and z -- 95 or less [20 or more] -- desirable -- x -- as for 30 or less [10 or more] and z, 85 or less [50 or more] are [x / 20 or less / 5 or more / and y] still more preferably good [30 or less / 0 or more / and y / 40 or less / 5 or more / and z / 90 or less / 40 or more]. FexCo 100-x It is an atomic composition ratio and, as for x, 50 or less [0 or more] are good. Moreover, alloying elements, such as Pt, may be added to the 2nd magnetic layer for the purpose, such as **** of coercive force, and corrosion resistance improvement.

[0040] In case a current is perpendicularly supplied to a film surface at the time of playback, it is made for electronic tunneling to occur from the 1st magnetic layer 1 to the 2nd magnetic layer 2 using an insulating layer thin as the 1st and 2nd magnetic layer 1 and a non-magnetic layer 3 between two in a spin tunnel film configuration. If the ferromagnetic tunnel junction which the electronic states of the upward spin in a Fermi surface and downward spin differ, and such a magnetic-thin-film memory device of a spin tunnel mold becomes from a ferromagnetic, an insulator, and a ferromagnetic using such a ferromagnetic metal since conduction electron has started spin polarization in the ferromagnetic metal is formed, in order to tunnel conduction electron, with the spin maintained, according to the magnetization condition of both the magnetic layers 1 and 2, a tunnel probability changes, it will serve as change of tunnel resistance and it will appear. Thereby, when the magnetization direction of the 1st magnetic layer 1 and the 2nd magnetic layer 2 is this direction, resistance between the 1st and 2nd magnetic layer 1 and 2 is small, and resistance becomes large when the magnetization direction of the 1st magnetic layer 1 and the 2nd magnetic layer 2 is an opposite direction.

[0041] Since, as for this resistance, the one where the difference of the density of states of upward spin and downward spin is larger becomes large and a bigger regenerative signal is acquired, as for the 1st magnetic layer 1 and the 2nd magnetic layer 2, it is desirable to use a magnetic material with the high rate of spin polarization. The 1st magnetic layer 1 and the 2nd magnetic layer 2 select Fe with the large amount of polarization of the vertical spin in a Fermi surface, and, specifically, select Co as the 2nd component. It is desirable to choose Fe, Co, and nickel from the ingredient used as the principal component, and to more specifically use them. Preferably, Fe, Co, FeCo, NiFe, NiFeCo, etc. are good. Specifically, Fe, Co, nickel72Fe28, nickel51Fe49, nickel42Fe58, nickel25Fe75, and nickel9 Fe91 grade are mentioned. Furthermore, the 1st magnetic layer 1 has NiFe, NiFeCo, more desirable Fe, etc., in order to make coercive force small, and in order to enlarge coercive force, the ingredient which uses Co as a principal component is desirable [the magnetic layer / the 2nd magnetic layer 2].

[0042] Next, the thickness of the 1st magnetic layer 1 of a magnetic-thin-film memory device and the 2nd magnetic layer 2 exceeds 100A, and it is desirable that it is 5000A or less. When this uses [1st] an oxide for a non-magnetic layer 3, the magnetism of the interface by the side of the non-magnetic layer of a magnetic layer becomes weaker under the effect of an oxide, and a large thing is mentioned when this effect of thickness is thin. It is because several 10A of aluminum remains when introducing oxygen, oxidizing it and creating after forming aluminum for the non-magnetic layer of an aluminum oxide, a magnetic layer becomes large when this effect is 100A or less, and a suitable memory property is not acquired [2nd]. When a memory device is made detailed to especially submicron one the 3rd, the memory maintenance engine performance of the 1st magnetic layer 1 is because the maintenance function of fixed magnetization of the 2nd magnetic layer 2 declines again. Moreover, since there are problems, like the resistance of a cel becomes large too much when too thick, 5000A or less is desirable and 1000A or less is more desirably good.
[0043] Next, if the ingredient of a non-magnetic layer 3 is explained, first, the magneto-resistive effect by spin tunneling is used, and a non-magnetic layer 3 must be an insulating layer, in order that an electron may hold and tunnel spin. All of non-magnetic layers 3 may be insulating layers, or the part may be an insulating layer. By making a part into an insulating layer and making the thickness into the minimum, a magneto-resistive effect can be heightened further. Moreover, as an example made into the oxidizing zone which oxidized the non-magnetic metal film as a non-magnetic layer 3, some aluminum film is oxidized in air and it is aluminum 2O3. The example which forms a layer is given. a non-magnetic layer 3 -- from an insulator -- becoming -- desirable -- aluminum-oxide AlOx, alumimium nitride AlNx, silicon oxide SiOx, and silicon nitride SiNx it is -- a thing is desirable. Moreover, NiOx It is good also as a principal component. This is NiOx, although it is required for the suitable potential barrier for the energy of the conduction electron of the 1st magnetic layer 1 and the 2nd magnetic layer 2 to exist in order for a spin tunnel to occur. It is because it is comparatively easy to obtain this barrier and a manufacture top also has it, when considering as a principal component. [advantageous]
[0044] Moreover, as thickness of a non-magnetic layer 3, it is about several 10A uniform layer, and, as for the thickness of the insulating part, it is desirable that it is [5A or more] 30A or less. That is, when it is less than 5A, it is because the 1st magnetic layer 1 and 2nd magnetic layer 2 may short-circuit electrically, and is because electronic tunneling will stop being able to occur easily if it exceeds 30A. Furthermore, 4A or more 25A or less is desirably good, and 6A or more 18A or less is more desirably good.
[0045] Next, in a spin dispersion film configuration, in order to acquire the magneto-resistive effect by this spin dependence dispersion using the magneto-resistive effect produced by spin dependence dispersion, it is good to use the metal layer which consists of a good conductor as a non-magnetic layer 3. The magneto-resistive effect by this spin dependence dispersion originates in dispersion of conduction electron changing greatly with spin. Namely, although resistance becomes small since the conduction electron with the spin of magnetization and the same direction is seldom scattered about, as for the conduction electron with the spin of magnetization and the opposite sense, resistance becomes large by dispersion. Therefore, when magnetization of the 1st magnetic layer 1 and the 2nd magnetic layer 2 is the opposite sense, it becomes larger than the resistance in the case of being the same direction.
[0046] The 1st magnetic layer 1 in a spin dependence dispersion film configuration, the 2nd magnetic layer 2, and a non-magnetic layer 3 are explained. First, the 1st magnetic layer 1 is for reading the magnetization information saved at the 2nd magnetic layer 2 using giant magneto-resistance while forming the 2nd magnetic layer 2 and annular loop formation. As for the 1st magnetic layer 1, it is desirable to use as an amorphous alloy which uses Co and Fe as a principal component, using nickel, Fe, and Co as a principal component. For example, magnetic films, such as NiFe, NiFeCo, FeCo, and CoFeB, are mentioned. Moreover, the amorphous magnetic substance, such as CoFeB with the presentation of Co84Fe nine B7 and Co72Fe8 B20 grade, may be used.
[0047] The 2nd magnetic layer 2 is a magnetic layer for mainly saving magnetization information, and the sense of magnetization is determined according to "0" or "1" information. The 2nd magnetic layer 2

needs that giant magneto-resistance occurs efficiently as well as the 1st magnetic layer 1, and to be able to save a magnetization condition at stability. Magnetic films, such as Fe, FeCo, and Co, are used as the 2nd magnetic layer 2, using the magnetic layer which uses Fe and Co as a principal component. Moreover, alloying elements, such as Pt, may be added. Since coercive force will become small if Fe is added to Co, and coercive force will become large if Pt is added, it is the 2nd magnetic layer 2 For example, $Co_{100-x-y} Fe_x Pt_y$ It can carry out, elementary composition x and y can be adjusted, and coercive force can also be controlled. The coercive force of the 1st magnetic layer 1 can be similarly adjusted in the amount of alloying elements, such as a presentation ratio of Fe and Co, and Pt.

[0048] The thickness of the 1st magnetic layer 1 needs to set up so that the giant magneto-resistance of a dispersion mold may occur efficiently. The distance which saves the sense of spin and can move by CPP-MR, i.e., spin diffusion length, serves as an important factor. If the thickness of the 1st magnetic layer 1 becomes large sharply from an electronic mean free path, since the effectiveness will specifically fade in response to phonon dispersion, it is desirable that it is at least 200A or less. Furthermore, 150A or less is preferably good. However, since the resistance of a cel becomes small, and a regenerative-signal output decreases and it becomes impossible to hold magnetization when too thin, 20A or more is desirable and 80 moreA or more is desirable.

[0049] It is required to set up so that the giant magneto-resistance of a dispersion mold may occur efficiently like [the thickness of the 2nd magnetic layer 2] the case of the 1st magnetic layer 1, and it is desirable that it is at least 200A or less. Furthermore, 150A or less is preferably good. However, since the memory maintenance engine performance deteriorates, a regenerative-signal output decreases, the resistance of a cel becomes small and it becomes impossible to hold magnetization when too not much thin, 20A or more is desirable and 80 moreA or more is desirable.

[0050] Since near and adhesion also have a magnetic layer and good Fermi energy level, when the magnetization direction changes consisting of a good conductor and using Cu as a principal component preferably, the non-magnetic layer 3 is convenient although a big magnetic-reluctance ratio is obtained that it is easy to produce resistance in an interface. Moreover, as for the thickness of a non-magnetic layer 3, it is desirable that it is [5A or more] 60A or less. Moreover, since a magnetic-reluctance ratio will become high, and a higher S/N ratio is obtained, it is [be / it / if / it prepares with the magnetic layer which uses Co as a principal component between the 1st magnetic layer 1 and non-magnetic layer 3, between the 2nd magnetic layer 2 and non-magnetic layer 3 or between the 1st magnetic layer 1 and non-magnetic layer 3, and between the 2nd magnetic layer 2 and non-magnetic layer 3,] desirable. Its 20A or less is desirable, and in order for the thickness of the layer which uses Co in this case as a principal component to demonstrate effectiveness, its 5A or more is desirable. Moreover, in order to raise S/N, the laminating of this unit may be carried out for the 1st 2/non-magnetic layer 3 of 2nd magnetic layer of 3/of 1/non-magnetic layers of magnetic layers as one unit. Although its MR ratio becomes large and is so desirable that there are many groups which carry out a laminating, since MR magnetic layer becomes thick and needs many currents when it is made [many / not much], the count of a laminating is still more preferably good 40 or less sets of to prepare in about 3-20 sets.

[0051] Since coercive force will become small if control of the coercive force of the 1st and 2nd magnetic layer 1 and 2 adds Fe to Co, and coercive force will become large if Pt is added, it is $Co_{100-x-y} Fe_x Pt_y$, for example. What is necessary is to carry out, to adjust elementary composition x and y, and just to control coercive force. Moreover, since coercive force can be heightened also by making high substrate temperature at the time of membrane formation, the substrate temperature at the time of membrane formation may be adjusted as the control approach of another coercive force. This approach and the method of adjusting the presentation of the ferromagnetic thin film mentioned above may be combined.

[0052] In addition, without restricting to the configuration of drawing 1 , drawing 6 , and drawing 7 , this invention prepares an antiferromagnetism layer in contact with the non-magnetic layer 3 of the 2nd magnetic layer 2, and the field of the opposite side, and this antiferromagnetism layer and 2nd magnetic layer 2 may carry out switched connection of it, and it may fix magnetization of the 2nd magnetic layer 2. Switched connection with an antiferromagnetism layer enables it to enlarge coercive force of the 2nd

magnetic layer 2. In this case, since it is also possible to use the same ingredient as the 1st magnetic layer 1 and 2nd magnetic layer 2, in order to enlarge coercive force, it has not said that MR ratio is sacrificed and the width of face of selection of an ingredient spreads. As an antiferromagnetism layer, nickel oxide NiO, iron manganese FeMn, cobalt oxide CoO, etc. can be used.

[0053] Next, record of the information on a memory device is performed by generating a larger field than the flux reversal field (coercive force) of a memory layer according to a record current as above-mentioned. Therefore, it depends for a field required for record on the coercive force of a memory layer. Hereafter, in order to investigate the magnitude of a field required for record, the invention-in-this-application person produced the memory device with the memory layer from which coercive force differs, and tried the evaluation experiment.

[0054] With the configuration of the memory device shown in drawing 7 , it produced 100 coercive force of a memory layer at a time for the memory cell which serves as the conductor 5 with a diameter of 0.12 micrometers from a NiFe detection layer / AlOx/Co memory layer with a bore [of 0.14 micrometers], and an outer diameter of 0.30 micrometers respectively as 2, 4, 5, 10, and 12 (Oe). Record of "0" or "1" was performed to these memory cells. The magnitude of the field generated from the current passed on a write-in line was almost equal to the coercive force of a memory layer, or was made into the magnitude which it exceeds a little. The die length of a conductor 5, i.e., the die length of a current path, was set to 2 micrometers. Then, the information on each cel was reproduced and the number of each of the normal cel in which recording information is held certainly, and the defect cel in which recording information has disappeared was investigated.

[0055] A result is shown in Table 1. The defect cel to the whole number of cells carried out the error rate comparatively, and it was defined. When magnitude of the field generated from the write-in line current was set to 5 (Oe), the error rate became 1% and became 0% above 10 (Oe). Moreover, the error rate became 50 or 90% respectively, and informational maintenance was difficult at 2 (Oe) and 4 (Oe). giving redundancy by addition of an error correction function as memory, if an error rate is about several% of level -- an error rate -- 0% -- ** -- it is possible to carry out and to carry out record playback correctly. From the above result, a write-in current field is understood that more than at least 5 (Oe) is required, and more than 10 (Oe) is desirably good.

[0056]

[Table 1]

書込み電流磁界 (Oe)	メモリ層保磁力 (Oe)	正常セル個数	不良セル個数	誤り率 (%)
2	2	10	90	90
4	4	50	50	50
5	5	99	1	1
10	10	100	0	0
12	12	100	0	0

Next, in order to investigate the upper limit of the die length of a current path, the invention-in-this-application person changed the die length of a current path, produced the memory cell of the same configuration as previous explanation, and he conducted the record playback experiment. It produced the 100 die length of a current path at a time respectively as 0.5, 1.0 and 2.0, and 3.0 or 4.0 micrometers. Record of "0" or "1" was performed to these memory cells, and the magnitude of the field generated from the current passed on a write-in line set coercive force of 10 (Oe) and a memory layer to 8 (Oe). A result is shown in Table 2. It became in 1.0 micrometers, and when the die length of writing was set to 2 micrometers, the error rate became 2%, and it became 0% by 0.5 micrometers 1%. Since it incorrect-recorded on the cel which adjoins since the long current path was established in the direction of thickness, it is presumed that the error rate worsened. From the above result, at least 2 micrometers or less are required for the die length of a write-in line, and it is desirably understood that 0.5 micrometers or less are [1.0 micrometers or less] still more desirably good.

[0057]

[Table 2]

長さ(μm)	正常セル個数	不良セル個数	誤り率(%)
0.5	100	0	0
1.0	99	1	1
2.0	98	2	2
3.0	50	50	50
4.0	0	100	100

[0058]
[Effect of the Invention] Since a degree of integration is not only raised, but according to this invention it can make a 1-bit cell size small and sufficient field for record can be generated by setting the die length of the current path which records information by the field to generate to 0.05 micrometers or more and 2 micrometers or less using the 1st and 2nd magnetic layer of closed magnetic circuit structure as explained above, it is stabilized, and information can be recorded, it is stabilized and information can be saved.

[Translation done.]

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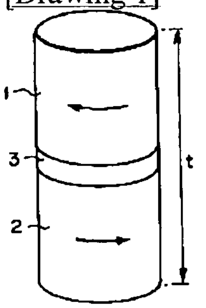
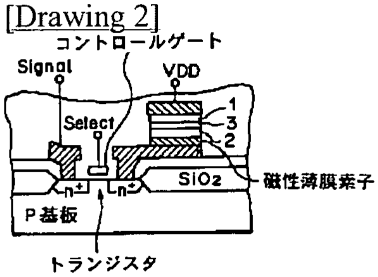
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

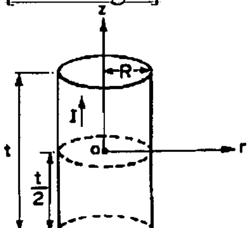
[Drawing 1]



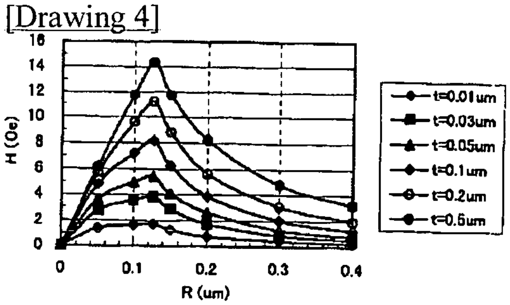
[Drawing 2]



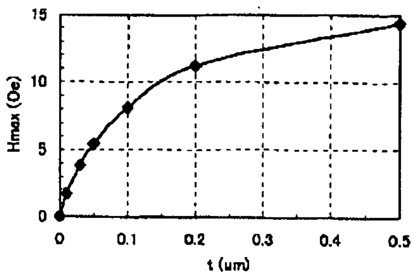
[Drawing 3]



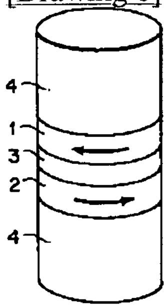
[Drawing 4]



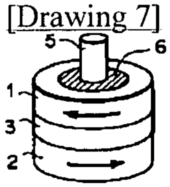
[Drawing 5]



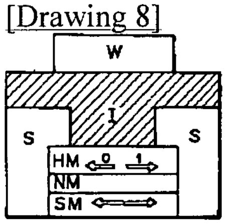
[Drawing 6]



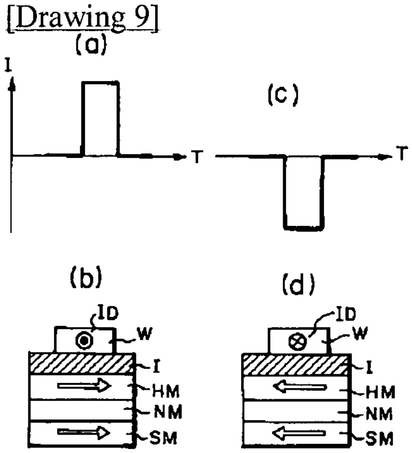
[Drawing 7]



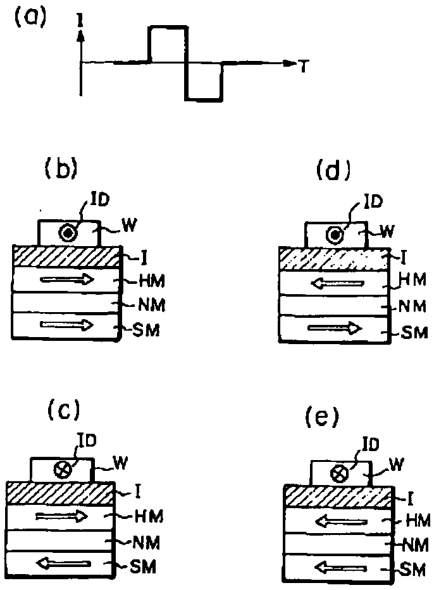
[Drawing 8]



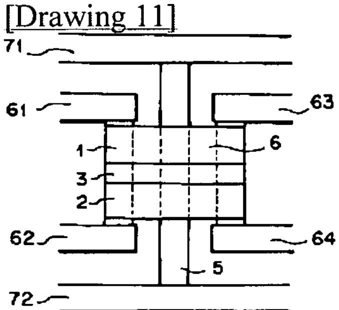
[Drawing 9]



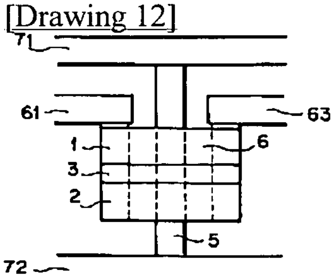
[Drawing 10]



[Drawing 11]



[Drawing 12]



[Translation done.]